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A NEW SPECIES OF ATHLETA AND A NOTE ON THE MORPHOLOGY OF ATHLETA PETROSA.

BY BURNETT SMITH.

INTRODUCTION.

Though the present paper is intended primarily to show some of the variations and mutations exhibited by one of our Eocene Volutoid stocks, recent work in nomenclature has necessitated certain changes of generic names, and therefore a brief explanation of these changes is essential to a proper understanding of the forms here considered.

In April, 1906, Dr. Dall[1] called attention to the fact that the type of Swainson's genus *Volutilithes* is not *Voluta spinosa* (which had been previously accepted by most authors), but *Voluta muricina* Lam. A similar observation was made by Mr. R. Bullen Newton[2] in June, 1906. Taking *Voluta muricina* as the type for the genus *Volutilithes,* it is plainly evident that such forms as *Voluta spinosa* of Lamarck and *Voluta petrosa* of Conrad must be furnished with a separate generic designation and not included in the genus *Volutilithes.* In selecting a name for these forms the writer has followed the suggestions of M. Cossmann[3] and revived Conrad's *Athleta.*[4] The type of *Athleta* is the European *Athleta rarispina.*

The forms studied in the present paper are all either specifically identical with or else closely related to Conrad's *Voluta petrosa,* which for so many years has been familiar to American palæontologists as *Volutilithes petrosus.* As the author has recently stated,[5] the study of large and carefully collected series from the Gulf States has convinced him that the forms described as *Athleta tuomeyi* by Conrad are nothing but races of his *Voluta petrosa* which have been subjected to an unfavorable environment. "They are of one genetic stock, and the differences can in no sense be regarded as generic; in fact they are not even specific."

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[1] *The Nautilus,* "Note on some Names in the Volutidæ," p. 143.

[2] "Note on Swainson's Genus *Volutilithes,*" *Proc. Malac. Soc. Lond.,* June, 1906, p. 100.

[3] *Revue Critique de Paléozoologie,* p. 222, Oct., 1906.

[4] "Synopsis of the Genus Cassidula and of a proposed new genus Athleta," *Proc. Acad. Nat. Sci. Phila.,* Vol. VI, 1852–3.

[5] *The Nautilus,* March, 1907, p. 131.

Now *Athleta rarispina* certainly has generic affinity with both Conrad's *Athleta tuomeyi* and Lamarck's *Voluta spinosa.* When we compare Lamarck's *Voluta spinosa* and Conrad's *Voluta petrosa,* no differences which can be regarded as other than specific are observed. We have therefore at least four species of *Athleta,* two American and two European. The two American are connected by every gradation of intermediate and cannot be considered as specifically distinct. The European forms are separate species.[6] In spite, therefore, of minor morphologic differences, and of discrepancies in the time range and in the geographical distribution, we must regard these forms as belonging to one generic group and apply the name *Athleta* to them all. *Athleta petrosa* would then include both *Voluta petrosa* and *Athleta tuomeyi;* the value of the designation *tuomeyi* should, however, in no case be more than subspecific.

The assemblages which may be grouped under the specific name *Athleta petrosa* are widely distributed in our Gulf Eocene. The race from any particular locality or bed usually differs from other races, but nevertheless all of them possess so many characters in common that further specific division would be inadvisable. Every individual gradation and not a few racial gradations may be found to connect the normal *Athleta petrosa* with the abnormal *Athleta petrosa tuomeyi.* As far as the author knows, it is only at two localities that we find forms associated with *Athleta petrosa* which, though closely related, must be considered as distinct species.[7] The cases in question are at Claiborne, Alabama, where the closely related associate species is *Athleta sayana,* and at St. Maurice, Louisiana, where the closely related associate is here designated as the new species *Athleta clayi.*

The races of *Athleta petrosa* and their allies from the Alabama-Mississippi region have been considered in a previous paper.[8] In their case, thanks to the work of Prof. Eugene A. Smith and Mr. Lawrence C. Johnson,[9] it is possible to arrange the races in chronologic order. In the present study the races discussed are mostly from the Eocene beds west of the Mississippi River, and unfortunately the stratigraphy of the minor divisions is there only poorly understood. The researches of Prof. Gilbert D. Harris have, it is true, done much to make clear the succession in Louisiana and Texas; but it is still impossible to ascertain the relations of the less important beds with each other or with their time equivalents in the standard sections of Alabama. In this western Gulf region we have three well defined formations in which *Athleta petrosa* and its allies occur. These are the Lignitic, Lower Claiborne and Jackson.

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[6] Dr. Dall (*Trans. Wag. Inst.,* Vol. 3, p. 75) says: "In America, however, the deposition of callus never became normal and regular, though in Europe *A. rarispina* and *A. ficulina* Lam. exhibit a normal, *Cassis*-like expansion around the aperture of what, without it, is a typical *Volutilithes.*" At this time Dr. Dall regarded *Voluta spinosa* as the type of *Volutilithes.*

[7] *Volutilithes precursor* of Dall and *Volutilithes dalli* of Harris, though in the same genus with *Athleta petrosa,* are not very nearly related to it.

[8] "Phylogeny of the Races of Volutilithes petrosus," *Proc. Acad. Nat. Sci. Phila.,* May, 1906, p. 52.

[9] Bull. 43, *U. S. G. S.,* "Tertiary and Cretaceous Starta of the Tuscaloosa, Tombigbee, and Alabama Rivers," Eugene A. Smith and Lawrence C. Johnson.

MORPHOLOGY.

As with the races from the Alabama sections, we find that the *Athleta petrosa* assemblage from any one locality or horizon is apt to differ more or less from that found at another locality or horizon. Not infrequently certain individuals of a race will depart to some extent from the racial norm, but these make usually but a small minority of the assemblage. "In other words, the majority of specimens from any one locality or horizon show a certain stage of evolution."

Throughout the present paper the author has used the same terms which were employed in dealing with the Alabama forms. As before we have the smooth stage, curved rib stage, cancellated stage, spiny stage and senile stage. The senile and spiny stages may be separate or associated together in the same whorl. Rib, spiral, tubercle, spine, etc., are all used in the same sense, and the end of the first whorl is again placed (arbitrarily, of course) in the same position.

Athleta petrosa tuomeyi.

Sabinetown Race.

Locality.—Sabinetown, Texas.

Horizon.—Lignitic beds.

This series is small and the individuals are poorly preserved. There are no very young ones, and the shelly overgrowth produced by the protruded mantle is very extreme in the old individuals. This, together with the poor state of preservation, renders detailed morphologic work impossible. These forms are typically senile, the most marked feature being the monstrous shelly overgrowth which results from the protrusion of the mantle onto the preceding whorl. In addition they are very small and dwarfed. They resemble closely the Hatchetigbee forms of Alabama, but are even more extreme and dwarfed. If they are members of the same senile phylogenetic series which we find in Alabama they are indeed descendants of the Hatchetigbee Bluff Race. They may, however, be synchronous with any one of the Alabama senile groups, and be merely the expression of conditions which were much more unfavorable than those influencing the more eastern assemblages during Lignitic time.[10]

Athleta petrosa.

Lower Claiborne Races.

In the Alabama sections we find forms representing in a general way the *Athleta petrosa* main stock at a date as early as the Nanafalia Lignitic. In the western Gulf region no such normal types are known to the author from below the horizon of the Lower Claiborne beds. In other words the Lignitic forms from Texas, etc., are (as far as observed) abnormal, and even these senile representatives are rare. No evidence of the presence of these abnormal members has yet been presented by the sediments found above the Lignitic beds of this region.

The Lower Claiborne races of *Athleta petrosa,* then, may all be grouped as members of the *Athleta petrosa* main stock. As a rule each locality is characterized by a single, comparatively homogeneous race, the great majority of whose individuals differs more or less in certain minor characters from the races of other localities. Exceptionally, however, we find two very slightly different strains in the assemblage from a given place. These insignificant peculiarities may sometimes be important in locating the probable ancestry of later forms. Again, in a few places we find a well-defined race of *Athleta petrosa* accompanied by a very closely allied derived form, which has departed enough from its parent stock to be described as a distinct species.

The Lower Claiborne of Louisiana and Texas furnishes many good collecting grounds which afford excellent material for exhibiting the variations and mutations of *Athleta petrosa.* Nine localities which offer large series of well-preserved specimens have been selected, and the developmental shell stages of their races have been arranged in tabulated form. With the exception of Moseley Ferry all the localities chosen have comparatively homogeneous races of *Athleta petrosa.* At Moseley Ferry there are, however, two well-marked strains of *Athleta petrosa.* These two strains are very close, but one is of interest as foreshadowing the characters of the Jackson and Montgomery races of later time. It is greatly to be regretted that our knowledge of the stratigraphy will not permit us to arrange the Lower Claiborne races in chronologic order.

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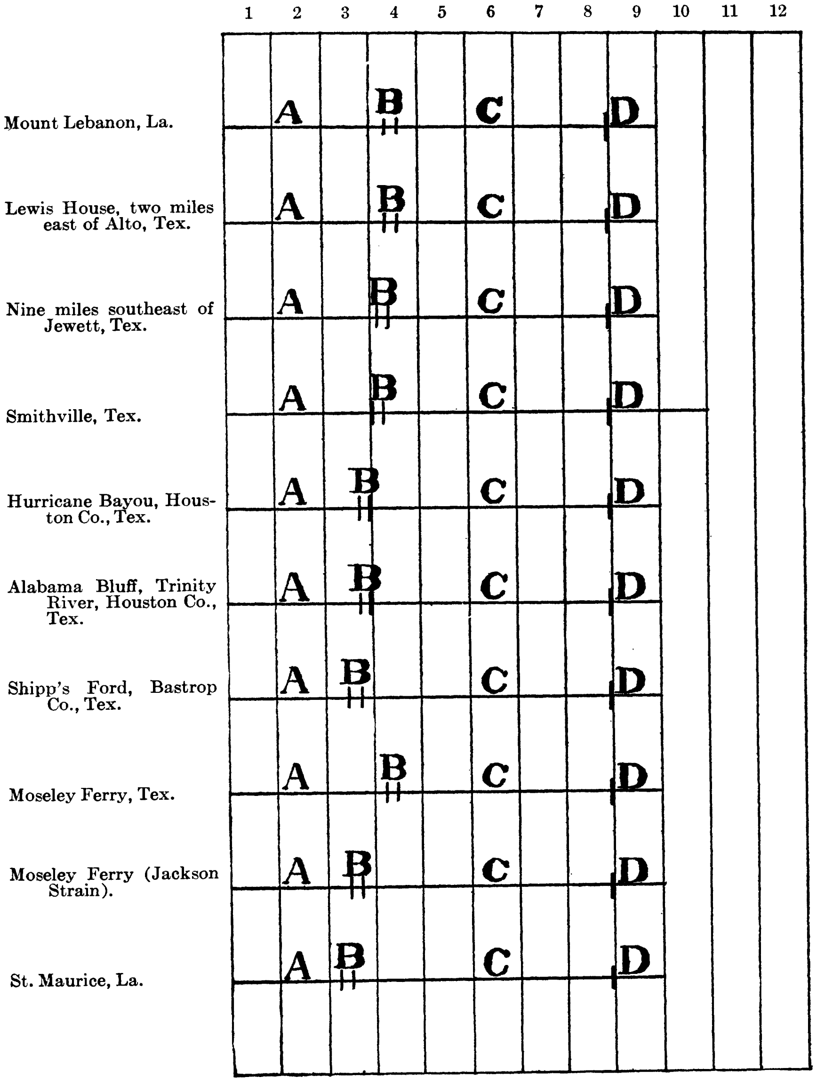
[10] The Sabinetown beds have usually been correlated with the Wood's Bluff beds of Alabama. See Gilbert D. Harris and A. C. Veatch, *Geol. Surv. La.*, Rep. V, 1899, p. 67, and also A. C. Veatch, *Geol. Surv. La.*, 1902, p. 125.

In the following tables the figures stand for the whorl, while the letters are used for the different ontogenetic stages as follows:

A—Smooth stage.
B—Curved rib stage.
C—Cancellated stage.
D—Spiny stage.
E—Senile stage.
I—Individual variation.



	1	2	3	4	5	6	7	8	9	10	11	12
Mount Lebanon, La.		A		B		C			D			
Lewis House, two miles east of Alto, Tex.		A		B		C			D			
Nine miles southeast of Jewett, Tex.		A		B		C			D			
Smithville, Tex.		A		B		C			D			
Hurricane Bayou, Houston Co., Tex.		A	B			C			D			
Alabama Bluff, Trinity River, Houston Co., Tex.		A	B			C			D			
Shipp's Ford, Bastrop Co., Tex.		A	B			C			D			
Moseley Ferry, Tex.		A		B		C			D			
Moseley Ferry (Jackson Strain).		A	B			C			D			
St. Maurice, La.		A	B			C			D			

Table I.—Showing variability in the length of the smooth stage and relative constancy in the beginning of the spiny stage in the Lower Claiborne races of *A. petrosa*.

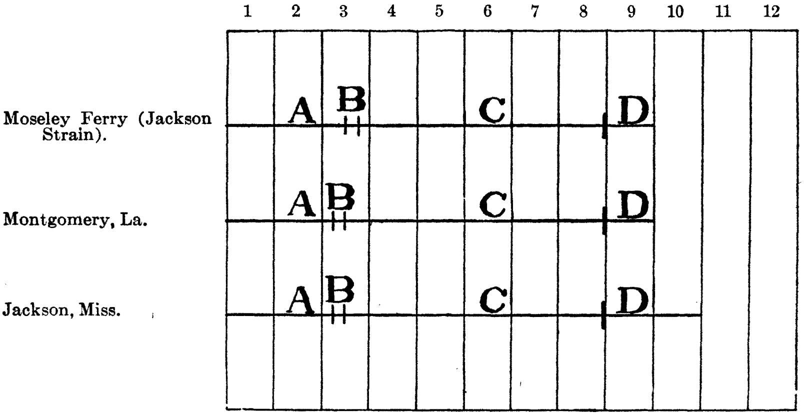
Athleta petrosa.

Montgomery Race.

Locality.—Montgomery, Louisiana.

Horizon.—Jackson beds.

The Montgomery race is, from a geological standpoint, cotemporaneous with the Jackson race of Jackson, Mississippi. In its early whorls it is perhaps a little less accelerated than the Jackson race. The following table will serve to illustrate its relations with the Mississippi forms and with the probable Lower Claiborne ancestor.



	1	2	3	4	5	6	7	8	9	10	11	12
Moseley Ferry (Jackson Strain).		A	B			C			D			
Montgomery, La.		A	B			C			D			
Jackson, Miss.		A	B			C			D			

TABLE II.—Showing slight acceleration of the curved rib stage and the beginning of the cancellated stage in the *A. petrosa* races of Jackson time. The Lower Claiborne Moseley Ferry form is introduced as a probable ancestor.

Athleta clayi n. s.[11]

Locality.—St. Maurice, Louisiana.

Horizon.—Lower Claiborne.

The more important morphological features of this species may be summed up as follows:

Whorl 1.—Smooth and rounded.

Whorl 2.—Smooth and rounded at first, but soon a very few untubercled but nearly straight ribs appear. These probably represent a somewhat suppressed and condensed curved rib stage. They are followed by the straight tubercled ribs of the cancellated stage. At first the suture tubercle is the larger, but a shoulder angle soon forms and the shoulder tubercle becomes dominant.

Whorls 3, 4.—Characterized by the cancellated stage. Much as in the latter part of whorl 2, but the ribbing above the shoulder grows weaker.

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[11] This species has been named in honor of Mr. Randolph Clay, of Philadelphia.

Whorls 5, 6.—Characterized by the cancellated stage, but toward the end of 6 the ribbing above the shoulder is gone and the suture tubercles are weak. The shoulder tubercle strengthens and the ribbing below it is well developed. Whorls covered with fine spirals from the shoulder downward, but they are stronger below on the branchial siphon.

Whorl 7.—Still characterized by the cancellated stage. The suture tubercle and the spirals immediately below the shoulder both disappear. The spirals are well developed, however, on the branchial siphon. Toward the end of the whorl the ribbing below the shoulder disappears and the shoulder tubercles become spine-like, so that the cancellated stage ends with the close of whorl 7.

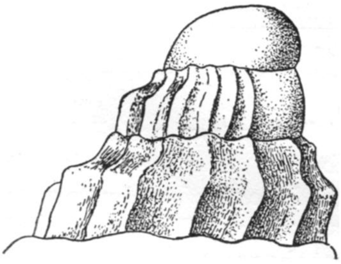

FIG. 1.

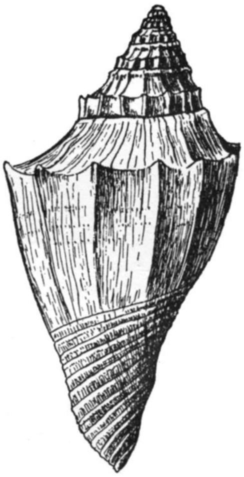

FIG. 2.

Fig. 1.—Apex of *Athleta clayi*. St. Maurice, Louisiana. In the second whorl the short and almost suppressed curved rib stage is seen passing into the tubercled ribs of the cancellated stage. Length about 1.2 mm.

Fig. 2.—*Athleta clayi*. St. Maurice, Louisiana. Mature individual exhibiting in its last whorl the features of the spiny stage. In the mature sculpture it is practically indistinguishable from the adult specimens of *A. petrosa.* Length = 27.5 mm.

Whorl 8.—Characterized by the spiny stage. Shoulder spines sharp. Spirals on the branchial siphon only. Shelly smoothing of the preceding whorl is slight.

Remarks.—This form is distinguished from the St. Maurice race of

Athleta petrosa by its large and swollen apex; by its smooth stage which occupies little more than one whorl; by its more or less suppressed curved rib stage, and by the earlier decline of the spirals immediately below the shoulder. The following table will serve to compare *Athleta clayi* with its associate, the St. Maurice race of *Athleta petrosa,* and also with a probable descendant, *Athleta sayana,* of Claiborne, Alabama.

	1	2	3	4	5	6	7	8	9	10	11	12
A. petrosa. St. Maurice, La.		A	B			C			D			
A. clayi. St. Maurice, La.	A	B			C			D				
A. sayana.[12] Claiborne, Ala.	A	B		C			D	and I				

TABLE III.—Showing the greater amount of acceleration in *A. clayi* and *A. sayana.* The less accelerated *A. petrosa* is introduced for comparison.

In Table I the compared races of *Athleta petrosa* are all from one geological formation, the Lower Claiborne. As stated before it is not possible, with our present knowledge of the stratigraphy, to arrange them in the order of their geological succession. This is most unfortunate, for it can be seen at a glance that the races differ to a considerable extent in the acceleration of their shell features. These races may and undoubtedly largely do represent certain episodes in the time range of the stock, but we cannot say which ones are mutations and which ones variations. There appears to be no relation between geographical distribution and degree of acceleration, and even if there were it would mean nothing in view of our ignorance of the stratigraphy. Any attempt at a phylogenetic arrangement of these assemblages, having as its basis the degree of acceleration, is very inadvisable. Such an arrangement would be founded on the assumption that an accelerated form must always and invariably occupy a higher horizon in the rock series than an unaccelerated form.

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[12] During 6, 7 and 8 many secondary riblets appear, and these with the spirals produce a secondary cancellation which must not be confused with the primary.

In these ten Lower Claiborne races it is evident that the early stages vary more than do the later stages. The end of the cancellated stage comes very constantly toward the close of whorl 8. The end of this stage is not as distinct as its beginning, and it is true that the table exaggerates slightly the sharpness of this termination of the cancellated stage. Though the change from the cancellated to the spiny stage is gradual it is usually accomplished within half a whorl, and this transformation takes place with great regularity during the latter part of whorl 8. To sum up, the table may slightly exaggerate the sharpness of the change, but it in no way exaggerates the fact that the end of the cancellated stage occupies in this series of forms a much more definite place in the ontogeny than does its beginning.

Table II shows that in the *Athleta petrosa* races of Jackson time the beginning of the cancellated stage is on the whole earlier than in the forms of the Lower Claiborne. In some cases this acceleration is quite marked, as is seen when we compare, for example, the Jackson or Montgomery races with the Mt. Lebanon race of Table I. The Lower Claiborne St. Maurice race of *Athleta petrosa* seems to have attained about the same degree of acceleration as the later races of Table II. The Lower Claiborne Moseley Ferry race, which exhibits the tendencies of the later Jackson time races, has been introduced into Table II as a probable ancestral form.

In Table III the Lower Claiborne race of *Athleta petrosa* from St. Maurice and the *Athleta clayi*, also of St. Maurice, are compared. *Athleta sayana* from the later Claiborne beds is shown as a probable descendant of *A. clayi*.

Taking all three tables into consideration, it is evident that the smooth stage is by far the most variable stage in *Athleta petrosa* and its derivatives, *A. clayi* and *A. sayana*. Still another remarkable fact is brought out by these tables when we examine the changes of the smooth stage in relation with the changes in the later stages. It is only in *Athleta sayana*, a form where the smooth stage has been restricted to a little over one whorl, that we find any marked modification of the characters of the spiny stage. Again, it is only in *A. sayana* that we find the spiny stage beginning at such an early point in the ontogeny as the sixth whorl.

In *Athleta clayi* and *A. sayana* the smooth first whorl is much larger than in any of the assemblages of *A. petrosa*. The apex of *A. sayana* is larger than the apex of *A. clayi*, and in addition the later stages of *A. sayana* are markedly different from those of *A. petrosa*. On the other hand, the later shell characters of *A. clayi* are almost identical (except for acceleration) with those of some of the Texas Lower Claiborne races of *A. petrosa.* In this particular respect *A. clayi* more closely resembles all the races of *A. petrosa* than it does *A. sayana.*

Athleta clayi is similar, then, to *A. petrosa* in its later stages, but similar to *A. sayana* in its smooth and curved rib stages.[13] It may be reasonably regarded as an intermediate between the *Athleta petrosa* main stock and *Athleta sayana.*

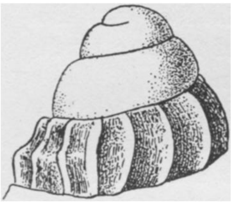

FIG. 3.

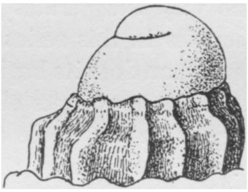

FIG. 4.

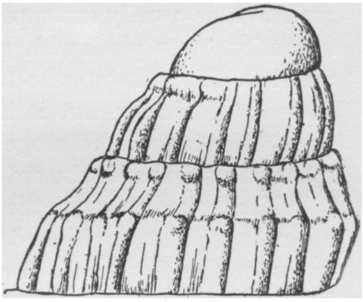

FIG. 5.

Fig. 3.—Apex of *Athleta petrosa* Con. St. Maurice, Louisiana. Showing the small first whorl and the relatively long smooth stage. In whorl 3 the curved ribs are seen passing into the tubercled ribs of the cancellated stage. Length about .75 mm.

Fig. 4.—Apex of *Athleta clayi.* St. Maurice, Louisiana. Shows the large and smooth first whorl. The tubercled ribs of the cancellated stage are displayed in whorl 2. Length about .8 mm.

Fig. 5.—Apex of *Athleta sayana* Con. Claiborne, Alabama. Shows the large smooth whorl and the smooth stage which is restricted to a little over one whorl. In whorl 2 the almost suppressed curved ribs are seen passing into the tubercled ribs of the cancellated stage. Length = 1.8 mm.

One more question is worth considering before we leave the discussion of the morphology. What is the meaning of this restriction of the smooth stage to a little over one whorl? If the size of the apex remained the same it would be best explained as an example of acceleration. The size of the first whorl, however, is not the same as in *Athleta petrosa,* but is larger in *A. clayi* and still larger in *A. sayana.* May not this change then represent only an enlargement of the veliger, rather than a case of true acceleration? The writer feels that with present data he is unable to solve this particular part of the problem. Though the cause of this change may be unknown the change itself is unquestionable, and in the probable phylogeny of this particular series of forms it precedes the modification of the later shell stages.

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[13] The author realizes perfectly that the propriety of separating *A. clayi* from *A. petrosa* may be questioned by some workers. Those who object to his arrangement will probably bring up the frequently cited case of Sturany's ***Fusus bifrons*** (Gastropoden des Rothen Meeres). Judging from the figures it would seem, however, that Sturany is dealing with what would be regarded by most systematists as two distinct species.

PROBABLE PHYLOGENETIC RELATIONS.

The Lower Claiborne races of *Athleta petrosa* show not a little racial variation especially in the smooth stage. They are nevertheless typical examples of the main stock. The later Claiborne race of Alabama probably owes its origin to some such assemblage as the first strain from the Lower Claiborne of Moseley Ferry. The second strain from Moseley Ferry—that is the one which shows such marked Jackson tendencies—is a probable ancestor which, through acceleration and the multiplication of plaits, passed into the Montgomery and Jackson races of Jackson time.

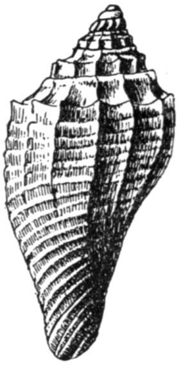


FIG. 6.

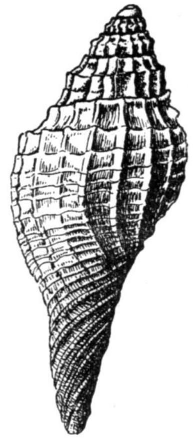


FIG. 7.

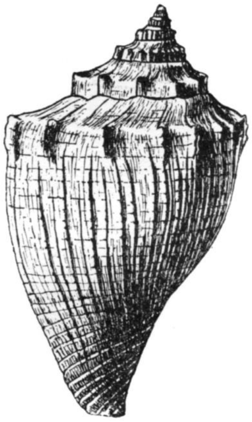


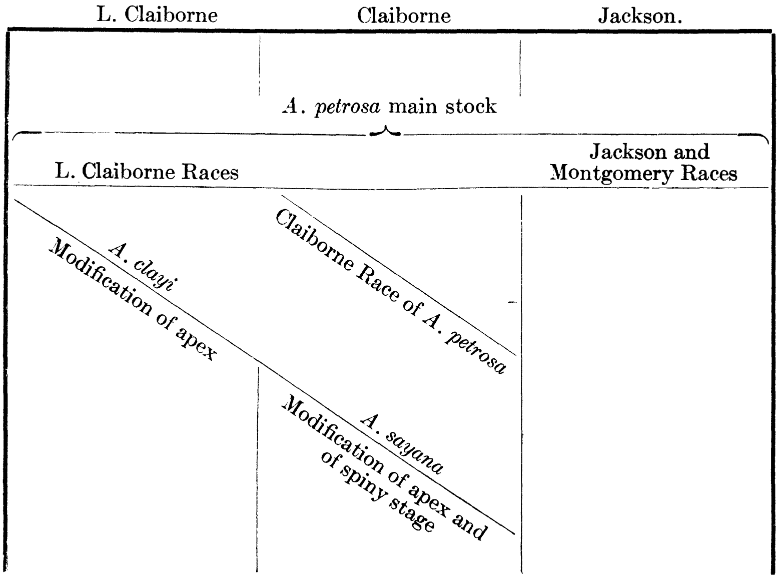
FIG. 8.

Fig. 6.—*Athleta petrosa* Con. St. Maurice, Louisiana. Immature individual exhibiting the sculpture of the cancellated stage. Length = 10 mm.

Fig. 7.—*Athleta clayi*. St. Maurice, Louisiana. Immature individual exhibiting the sculpture of the cancellated stage. Length = 12 mm.

Fig. 8.—*Athleta sayana* Con. Claiborne, Alabama. Mature individual showing in the sculpture of its later whorls marked departures from the *A. petrosa* main stock. The secondary cancellation is shown in the last whorl. Length = 48 mm.

Athleta clayi is almost identical with the examples of *A. petrosa* main stock in everything except its smooth stage. In its smooth stage it approaches *Athleta sayana* of the later Claiborne beds of Alabama. We are reasonably safe in concluding that *A. sayana* was derived from the *A. petrosa* main stock through the Lower Claiborne *A. clayi*. In this case the first change was a modification of the apical characters (*A. clayi*), and the second change was modification in the features of the spiny stage (*A. sayana*). The following table probably comes reasonably close to the phylogeny of these forms.



It will be seen that in the above scheme the Claiborne race of *Athleta petrosa* is placed in a position which indicates a slight divergence from the main stock. This change in its characters is attributed to the local nature of the Claiborne Sands environment.[14] The Claiborne race of *A. petrosa* is the type of the species, and this is just one example of what is frequently encountered in dealing with large series of races or individuals, namely, that the specific type may not be the most typical expression of the actual specific group.[15]

The races of *Athleta petrosa* which are displayed in the Lower Claiborne deposits of Texas and Louisiana appear to constitute a veritable metropolis. In this Lower Claiborne metropolitan assemblage was evolved *Athleta clayi*. The Claiborne race of *A. petrosa* and *A. sayana* of the Alabama Claiborne Sands represent local conditions, and clearly show their origin to have been among the more generalized forms of the Lower Claiborne.

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[14] See A. C. Veatch, *Geol. Surv. La.*, 1902, p. 140.

[15] Prof. Henry S. Williams has observed that "species are often described for the *extreme form* rather than the *central stock*." He also lays stress on "the necessity of distinguishing the real specific group from the species as understood in literature."

The Jackson and Montgomery races are unquestionably the descendants of the Jackson strain in the Lower Claiborne metropolis and are not derived from the Claiborne forms.

Summary.

In this study of *Athleta petrosa* and its allies from the western Gulf region we find the geological series of the races less complete than in the Eocene beds east of the Mississippi River. The Texas Lignitic yields little material, but that little is quite similar to the senile forms of the later Lignitic of Alabama. Texas, however, gives us no such increasingly abnormal series as we find in the Alabama Lignitic. These abnormal forms are considered as derived (1) by migration and (2) by senile evolution from a theoretical metropolis situated farther seaward in a more typically marine environment than obtained in the waters of the Lignitic Gulf.

With the end of the Lignitic this metropolis is believed to have encroached northward. The *Athleta petrosa* races of the Texas and Louisiana Lower Claiborne represent this metropolitan assemblage. Among these Lower Claiborne forms we find foreshadowed the Jackson, Montgomery and Claiborne races of later time. In addition *Athleta clayi* has in this Lower Claiborne diverged from its parent stock, and illustrates one stage of that evolution which finally results in the Claiborne *Athleta sayana.* The Claiborne forms of Alabama indicate an adjustment to rather local conditions, while the succeeding Jackson is a widespread limestone which bears a clear water facies of the old metropolitan assemblage.

In dealing with the evolution of shell features in fossil gastropods it is necessary to select a group which exhibits change, but at the same time is certainly of one genetic stock. The forms considered in this paper fulfill both of these conditions. No one can doubt the common origin of the races and species in question, while the morphologic changes are evident.

It was shown in another paper that the Lignitic forms diverged from the main stock by an exaggeration and not by an acceleration of the marks of senility. Their peculiar evolution was attributed to uncongenial conditions. It was a violent reaction to an unfavorable environment. The morphologic modifications of the post-Lignitic forms are perhaps still more interesting as casting some light on the laws of gastropod evolution. Taking the normal species and races of Lower

Claiborne, Claiborne and Jackson time, we find that on the whole there is much more variation in the smooth stage than anywhere else in the shell. Among the Lower Claiborne races of *Athleta petrosa* the only changes worthy of notice are in the length of the smooth stage, while *A. clayi* has departed from *A. petrosa* only by a modification of its apical features. The later shell characters of *A. clayi* are almost identical with those of *A. petrosa*.

In the Claiborne Sands we have the Claiborne race of *Athleta petrosa* and *A. sayana*. The writer suggests that in the first case (*A. petrosa*) the local conditions produced a modification in the later stages of a form with a primitive apex—in other words a member of the *A. petrosa* main stock. In the second case (*A. sayana*) it is believed that these similar external conditions acted on a type such as *A. clayi*, and that this form with its already modified apex reacted more readily, so that the characters of its later shell stages departed to a considerable extent from those of *A. petrosa*.

In the more widely extended conditions of Jackson age the apices are not greatly changed in form, but the smooth stage is simply shorter. In other words the curved rib stage and the beginning of the cancellated stage are more accelerated.

From the data furnished by *Athleta clayi* and *A. sayana* it appears that in the normal races of *Athleta petrosa* and its normal allies marked modifications of the later shell stages are preceded by marked modification in the apex. In addition we can say for this restricted normal group at least that the apex is not only a variable feature, but the most variable feature which the shells furnish.[16]

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[16] The author is thoroughly convinced that the features of the apex must be used in classification with great caution. For this group at least Grabau's generalization does not hold. He says: "The smaller the taxonomic group the more nearly identical must be the earlier stages, since in a small group the members have not become widely separated from their common ancestor." (*Am. Nat.*, Vol. 36, p. 922.)